Renewable Energy 135 (2019) 378–389

Contents lists available at ScienceDirect

Renewable Energy

journal homepage: www.elsevier.com/locate/renene

Energy security in Israel and Jordan: The role of renewable energy sources

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ARTICLE INFO

Article history:
Received 3 March 2018
Received in revised form
16 November 2018
Accepted 9 December 2018
Available online 10 December 2018

Keywords:
Renewable energy
Energy security
Israel
Jordan
Solar
Wind

ABSTRACT

The usage of renewable energy sources increases the energy security because it brings extensive socio-economic benefits to Israeli and Jordanian populations, added pathways for bilateral cooperation and allows countries to achieve their climate mitigation goals. Israel and Jordan's energy mix are both dominated by fossil fuel usage and produce only 4% of their energy supply from renewable energy. Each have been affected by the events of the Arab Spring and the discovery of the Tamar and Leviathan natural gas fields. Both countries are vulnerable to political instability and climate change. Although Israel and Jordan have set targets to attain 10% renewable energy by 2020 the progress is slow and both countries may not reach this goal if the implementation occurs at the current pace. Current policies include feed-in tariffs and auctions for renewable projects. Both would benefit from increased investment electric in vehicles, better connectivity to the grid and greater cross-border cooperation.

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1. Introduction

The world is undergoing a transformation from fossil fuel abundance to resource scarcity, which requires a shift towards renewable energy [1]. In the past, global energy security has been shaped by the need to provide power sources for economic growth, to protect against terrorist threats and to reduce import dependency. Today, energy security planning is increasingly geared towards establishing a low-carbon economy. According to the International Energy Agency (IEA), energy security is defined as "the uninterrupted availability of energy supplies at an affordable price." The IEA notes the importance of both meeting environmental and economic needs in the long-term as well as reacting quickly to sudden changes in supply in short-term [2]. Similarly, the European Union (EU) bases its own energy policy around three key areas: (1) sustainability and climate change mitigation, (2) security of supply, and (3) economic competitiveness [3]. Kleber (2009) defines energy security through the "five Ss": surety, survivability, supply, sufficiency and sustainability [4]. Energy security is not a singularly political or technological concept but instead affects every level of society, from individual households being able to afford to turn on the lights to militaries powering their ships and planes. Providing adequate energy supplies at an affordable price is a critical component in stability, peace and prosperity [5].

Oftentimes, the various sectors of energy security are siloed. This decreases the likelihood of renewable and environmentally sustainable technologies being fully incorporated into all sectors of energy security efforts [6]. Ultimately, energy security is a fundamentally interconnected concept, both across a range of definitions, as well as across international borders. As ensuring fuel supply is critical to energy security, this often involves transboundary pipelines and numerous trade deals. In addition to geopolitical and macroeconomic concerns, energy security frameworks must address equitable access for citizens. The imperative to move the "bottom billion" in India and China out of energy poverty and

Abbreviations: AFEX, Arab Future Energy Index; BCM, billion cubic meters (10^9 cubic meters); BOO, build-own-operate (Jordan); EU, European Union; GHG, greenhouse gas; GWh, gigawatt hours; KTOE, thousands of tonnes of oil equivalent; LNG, liquid natural gas; IEA, International Energy Agency; INDC, Intended Nationally Determined Contribution; MENA, Middle East and North Africa; MW, Megawatts; MWI, Ministry of Water and Irrigation (Jordan); NEPCO, National Electric Power Company (Jordan); PV, photovoltaic; USD, United States dollar; ZEV, Zero Emission Electric Vehicle.

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https://doi.org/10.1016/j.renene.2018.12.036
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towards realizing universal energy access is a critical component in making energy systems sustainable [8]. In the Middle East and North Africa (MENA) region alone, there is a high electricity demand, with an expected 68% of the regional population living in cities by 2050 [9]. Without a targeted plan to address the rise in demand, the MENA region will not be able to properly provide energy for all of its citizens.

Furthermore, a 30% rise in demand for global energy by the year 2040 will exacerbate the need for renewable energies to emerge as a leading solution in the electricity sector. The success of the Paris Agreement and other recent international climate accords rely on the ability to provide energy security for future generations [10]. The Middle East is no exception; in the past 20 years, total primary energy demand in the region has tripled because of population growth [11]. Both Israel and Jordan are vulnerable to political, economic and environmental threats to energy stability. Therefore, the objective of this paper is to assess the energy security landscape in Israel and in Jordan and furthermore determine tenable pathways for added security through the usage of renewables. The analysis will utilize historical data and current national plans to both identify gaps and make policy recommendations.

2. Current energy situation in Israel and in Jordan

2.1. Israel

Israel has long been defined as an “energy poor state” because of its near total reliance on fuel imports from other nations. Historically, Israel has imported raw petroleum from Russia, Angola and Norway, states that do not share borders with Israel [12]. After the toppling of the regime in Egypt, terrorist attacks on sections of the Arab Gas Pipeline in the Sinai Desert cut off energy supply to the country, elucidating the need for more robust domestic energy supply. According to a 2015 report by David Sheppard, John Reed and Anjli Raval in the *Financial Times*, Israel imports up to 77%, or approximately 240,000 barrels per day, of its oil supply from Kurdistan [13]. Initially, Israel constructed its first oil refineries in the coastal city of Haifa in 1938 during the British Mandate. Under the steps taken within the 1988 Fuel Economy Reform, Israel's fuel economy moved from heavily regulated to decentralized [14]. Today, around 78% of fossil fuels in Israel are still imported from other countries [15].

In the past, Israel imported large amounts of crude oil and coal. Because of the recent discoveries of 32 billion cubic meters (BCM) of natural gas reserves in the Tamar gas field in 2009 and 460 BCM in the Leviathan field off the coast of Haifa in 2010, the dynamics of energy reliance have considerably shifted, creating a future almost devoid of coal and entirely replaced by natural gas [16]. The share of natural gas in the energy mix is currently at 26% of total primary energy supply in 2014 and is expected to triple by 2020 [17]. These discoveries were vital to Israel's energy independence; Israel's Energy Minister Yuval Steinitz said that it gives the country some “something to balance and influence” as opposed to its neighbors [18]. Natural gas allows Israel to both produce and export energy domestically rather than rely on imports.

In the next 20 years, Israeli consumption of electricity is expected to double due to rising living standards, population growth and an increase in extreme temperature days [19]. The population in Israel is expected to grow from 8.4 million in 2015 to 10.6 million in 2030 [20]. In addition, the Palestinian Territories, with a population of 3.76 million, rely on Israel for 100% of its fossil fuel imports and 87% of its electricity [21]. Between 1995 and 2005, the growth in demand for electricity increased at a rate of about 5% per year and only 3% per year between 2005 and 2015. Forecasted demand until 2030, based on the Israel Electric Company's figures, is at the rate of 2.3–2.8% [22].

Notably, Israel's transportation sector consumes the majority of fossil fuels in the country. According to the most recent IEA data on total final energy consumption, most, or 96%, of Israel's energy comes from fossil fuels (8782 ktoe), which include coal, oil and natural gas, and the remaining 4% comes from renewable energy (365 ktoe).

It also shows that of the fossil fuels consumed in Israel, 93.6% come from oil products and 6.4% come from natural gas, according to IEA data [23]. The Israel Electric Corporation operates the five largest and oldest power stations along the Mediterranean Coast, Orot Rabin, Reading, Rotenberg, Eshkol and Haifa. These five power stations utilize heavy fuel oil, natural gas or coal [24]. These power stations, especially the ones dependent on coal and heavy fuel oil can increase public health risk by adding to ambient, or outdoor, air pollution. Tel Aviv, with a metropolis population of 3.46 million and vast amounts of transportation usage and energy consumption experiences high levels of air pollution [25]. Outdoor air pollution is a major environmental health risk and can cause higher instances of premature deaths. Additionally, working to improve or replace aging and unhealthy infrastructure is one of the obstacles to attaining energy security. Israel signed the Paris Agreement on April 22, 2016 and has set a national target to reduce greenhouse gas (GHG) emissions by 2030. One notable component of the plan is to shut down the four most polluting coal units in the Orot Rabin Power Plant [26].

Importantly, Israeli energy supply is vulnerable to outside political events. For example, in 2012, during the Arab Spring, the ruling party ended the Arish-Ashkelon pipeline that supplied gas from Egypt to Israel [27]. When Israel imported its natural gas from Egypt, natural gas powered 40% of electricity generation. In 2010, of the natural gas used for electricity, 40% was supplied by the national Egyptian gas company [28]. In examining the energy mix in Israel's Total Primary Energy Supply (TPES) from 2007 until today, it is evident that during the Arab Spring, oil and coal consumption peaked while renewable energy and natural gas waned. Although they have not yet been targeted, the power stations along the Mediterranean coast are also vulnerable to attack.

Fig. 1 shows a steady breakdown of consumption of fuel source by sector and fuel type in Israel, from 2012 to 2015. It is evident that different use sectors have a varying makeup of energy sources.

The main sources of renewable energy are solar, wind and biomass. Israel has two thermal solar power stations at the Ashalim site in the Negev that produce 250 MW (MW) of power. As for wind energy technology, there is limited scale wind turbines located in the Golan Heights and government plans to build a 200 MW farm [29]. Additionally, Israel's biomass production occurs in two ways: through fermentation and biogas from solid waste or through burning waste. However, biomass in Israel will not make up a substantial part of Israel's renewable energy future because Israel's economy is not dominated by agriculture, like some of its neighbors, which have greater capacities to use this type of energy.

2.2. Jordan

Unlike its neighbors, Jordan has little or no indigenous hydrocarbon resources and imports more than 97% of its energy [30]. Additionally, Jordan owns limited natural freshwater resources. According to the Oil and Gas Journal, in January 2013, it was estimated that Jordan had natural gas reserves of about 5.7 BCM and 1 million barrels of oil.

Historically, Jordan's energy landscape has been impacted by relations between and among its Middle Eastern neighbors. In the 1980s, Jordan was completely dependent on Saudi Arabia for crude oil imports. Then, in 1984, Jordan began importing both fuel and

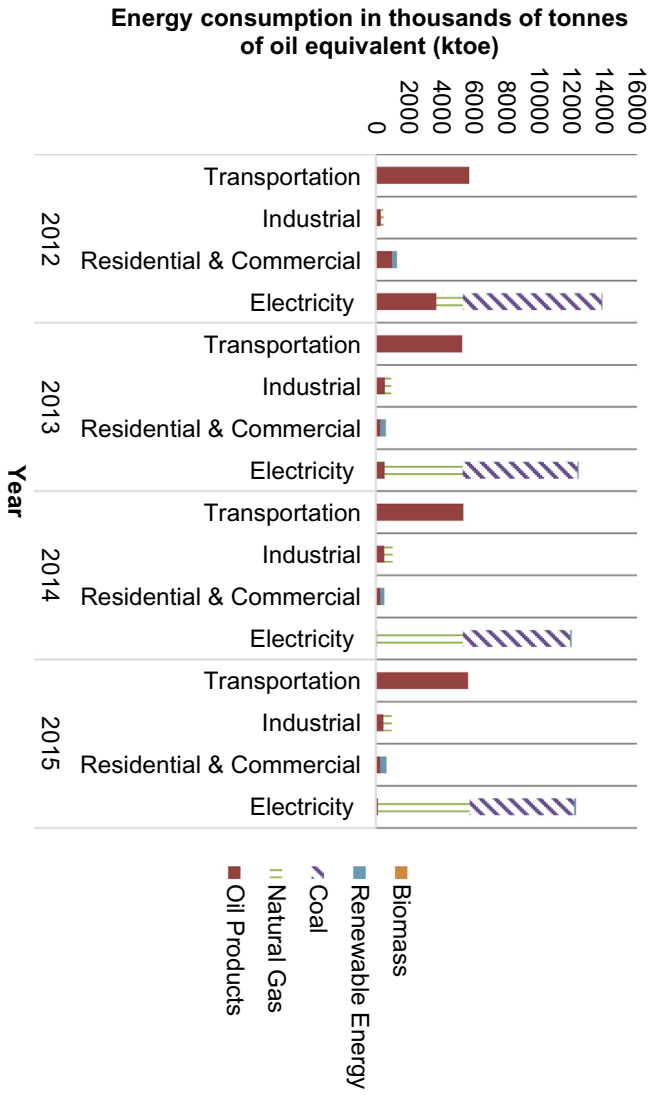

Fig. 1. Total final energy consumption in Israel breakdown by sector, type of fuel 2012–2015.

crude oil from Iraq after signing a counter-purchase agreement. After the Gulf War, Jordan stopped importing its energy from Iraq and switched to Saudi Arabia and Kuwait [31]. Crude oil is currently delivered at the Aqaba port. The Arab Gas Pipeline was completed in 2003 and Jordan's power generation was supplied by natural gas instead of heavy fuel oil [32].

In 2015, the Hashemite Jordanian government and the national electricity company, NEPCO, signed a purchase agreement with the owners of the Leviathan natural gas field to start providing Jordan with 15 BCM of natural gas per year. Despite some public pushback against negotiating with Israelis, this deal represented the largest economic cooperation between Israel and Jordan to date.

The population in Jordan, along with its energy demand, continues to grow and is estimated to be at about 6.388 million people. The population growth rate for 2014 was 3.86% and Jordan has the fifth highest migrant to population ratio in the world [33]. In Table 1, path towards projected energy demand by 2030 is shown [34]. Notably, in 2011, Jordan reached peak spending on energy at 19% of GDP or 4.02 billion USD, one of the highest percentages in the world. However, by 2016, spending on energy dropped to 7% of GDP [35]. Energy spending in Jordan during the Arab Spring

Table 1
Electricity demand forecast in Jordan.

Year	Megawatts (MW)	Growth (%)
2017	3282	3.7
2018	3423	4.3
2019	3570	4.3
2020	3724	4.3
2025	4667	4.5
2030	5816	4.5

increased because the dearth of supplies from the Sinai pipeline prompted the government to switch to expensive diesel fuel.

The vast majority of total final energy consumption is comprised of fossil fuels. The majority of Jordan's energy and fossil fuel consumption is in transportation, with few renewables used for transportation [36]. Just 4% of the energy consumed in Jordan comes from renewable sources (164 ktoe) and 96% is from fossil fuels (3997 ktoe).

In order to meet growing energy demand, Jordan added two new tri-fuel power plants, IPP3 and IPP4, close to Amman. Tri-fuel power plants use diesel oil, heavy fuel oil and natural gas. Additionally, Jordan has five other power stations that do not use all three types of fuel. They are located in Aqaba, in Samra, Al-Qatrana, Rehab, and Hussein [37].

Jordan's electricity operations are separated into three distinct types of activity: power generation, power transmission and electricity distribution. Jordan's National Electric Power Company (NEPCO), the national utility company, has jurisdiction over the high voltage lines, 132 kV and 400 kV in the country and the interconnection lines that connect Jordan to Syria and to Egypt. Electricity distribution, which operates on medium and low voltage lines and supplies end consumers with power, is provided by the Jordan Electric Power Company, the Irbid District Electricity Company and the Electricity Company [38].

Within Jordan's renewable energy sector, 97.6% of the energy comes from solar sources and the remainder is from biofuels. Originally endorsed by the 2005 National Energy Efficiency Strategy, Jordan is attempting to increase its renewable energy mix to 10% by 2020 [39].

Jordan's energy consumption by year, sector and type of energy is shown in Fig. 2. It is apparent that the use of natural gas in the electricity sector has grown considerably from 2012 to 2015, from 659 ktoe in 2012 to 1944 ktoe in 2015. However, there is a clear drop in the use of natural gas in 2014, due to dozens of attacks on the Arab Gas Pipeline. At one point, Egypt supplied 80% of Jordan's electricity [40]. The pipeline transported natural gas from Egypt to Jordan and its instability elucidated the need for a more secure energy supply in Jordan.

In Fig. 3, forecasted Jordanian energy consumption by fuel type for the years 2007, 2012, 2015 and 2020 in a medium energy demand scenario [41]. This chart shows the growth in overall total energy consumption as well as an increases in share from renewable energy, oil shale and diesel.

3. Renewable energy as energy security

Energy security depends on availability, affordability and resilience. Although throughout much of modern human history, energy security frameworks have tended to focus on the usage of fossil fuels, renewable energy itself can be a substantial pathway to developing energy security in the future. Because rising CO_2 emissions threaten the environmental health, sustainability and livelihood of our globe today, technologies that provide power but do not exacerbate global warming are necessary. Fossil fuels do not

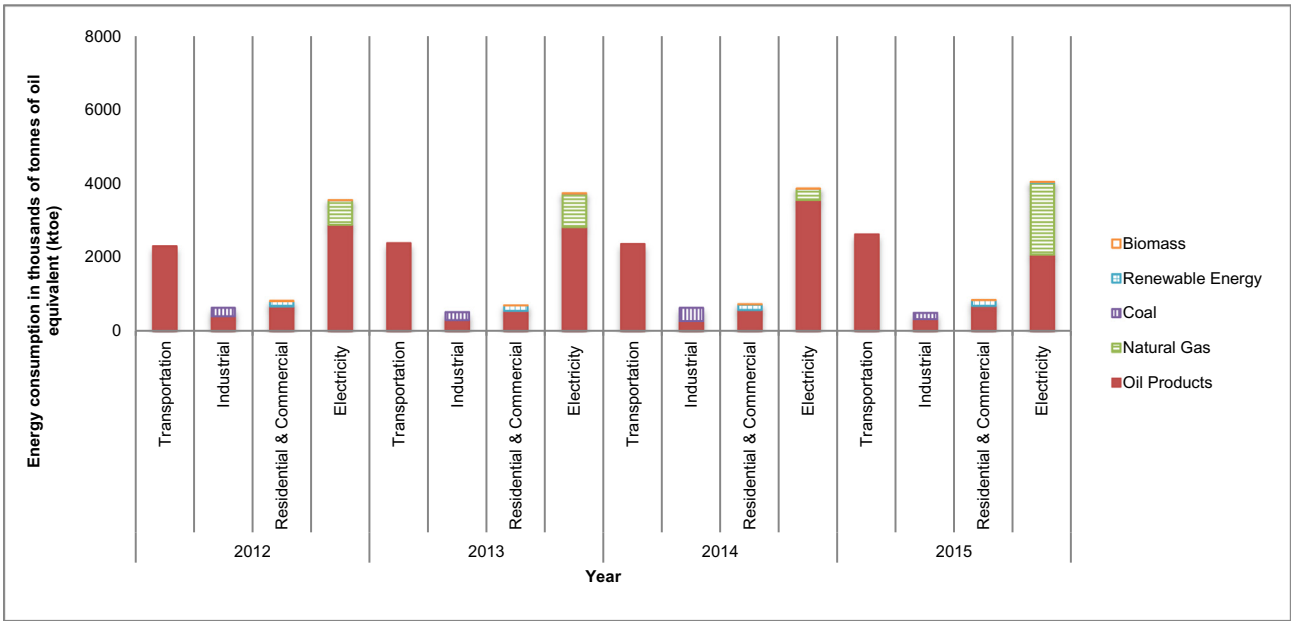

Fig. 2. Total final energy consumption in Jordan breakdown by sector, type of fuel 2012–2015.

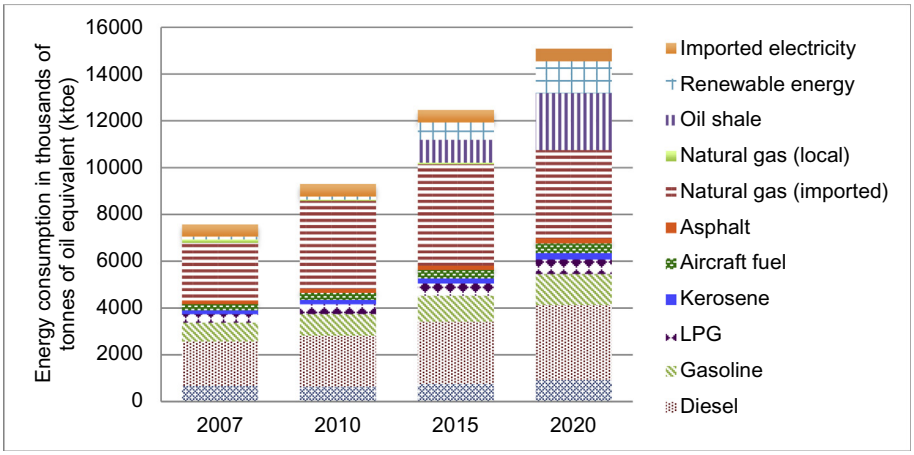

Fig. 3. Total final energy consumption by fuel in Jordan 2007–2020.

fit the given paradigm for energy security. Firstly, fossil fuels are limited in their availability and subject to supply constraints. Secondly, fossil fuels are costly and their prices are unstable. Although fossil fuels may currently have a comparative advantage, this may not be true in the future. Lastly, energy that comes from fossil fuels is vulnerable to hazards. Examples such as the Deepwater Horizon oil spill, which cost $62 billion United States dollars (USD) to cleanup, illustrated that fossil fuels can in fact be an insecure technology [42].

Moreover, renewable energy acts as an important mechanism towards achieving climate mitigation goals. The EU has a model for this. In 2012, the EU's GHG emissions declined by 17.9% from 1990 levels [43]. Not all of the emissions decline in the EU is attributable to the usage of renewable energy. Factors include the implementation of energy efficiency standards and switching from coal to natural gas. However, renewable energy is representing an increasing proportion of total energy consumption in the EU. In the EU's power sector alone, gross electricity generated from renewables more than doubled from 2003 to 2013 and provided more than a quarter of all total electricity in the EU in 2013 [44].

Furthermore, renewable energy projects can provide decision makers with prospects for positive cross border cooperation and joint initiatives. Jordan and Israel already work with partners across the globe to develop renewable energy projects and there is potential to share expertise with one another in building better solutions for a future that uses less carbon and fossil fuel resources. The development of individual or joint renewable energy projects between these two countries will significantly contribute to the energy security of both and will play a very important role as a catalyst for regional development. In 1995 an agreement was signed between Israel and Jordan involving renewable energy, this agreement did not lead to large scale collaboration if the field but it is believed that such agreements has many advantages that may lead to reduction of cost, shared usage of technical resources, minimizing errors and duplications and encouraging collaboration in research and development between researchers. The proposed Red Sea-Dead Sea Water Conveyance project is a model for energy and resource cooperation between the two countries because it

names Israeli, Jordanian and Palestinian Authorities as stakeholders invested in restoring the declining water level of the Dead Sea, establishing peace in the region and generating energy through water desalination [45]. Large-scale, inter-basin desalination efforts like this one can assist with energy storage and energy security through generating hydroelectric power and building positive relationships across both governments.

However, renewable energy is not a foolproof solution. There is much work to be done technologically, politically and financially in order to make a greater share of renewables viable in both Israel and Jordan. At its current state, fossil fuels are cheaper and more widely available than renewable energy. Governments must subsidize or provide tax incentives in order to incentive the usage and development of renewable energy. In the process of diversifying the energy mix in the region, both Israel and Jordan have looked to non-renewable sources. Liquid natural gas (LNG), which is not renewable, but yields less carbon emissions than other types of fossil fuels and has been discovered by Israel in vast reserves off the coast of the Eastern Mediterranean, is a prominent part of the energy conversation. Israel's natural gas reserves are currently estimated to supply the country for at least 25 years [46]. Jordan, on the other hand, does not have indigenous natural gas resources, which is why the instability around and attacks on the Egypt pipeline led the use of natural gas declined dramatically from 89% to 17% in 2012 [47].

Despite the prevalence of natural gas and other non-renewable energy sources in the region, renewables provide a longer, more sustainable path to energy security. Support for renewable energy initialized in the 1970s and 1980s concurrent with the rise of oil prices [94]. Because energy such as wind and solar can be produced domestically, they are not subject to political instability. Today, policymakers are aware that energy supply is subject to many kinds of risks. They can respond to the risks presented by energy insecurity through diversifying the energy mix, increasing the energy efficiency of existing infrastructures and managing demand. Renewable energy technologies have the potential to both directly tackle these risks and contribute to climate mitigation.

4. Renewable energy status and potential in Israel and Jordan

4.1. Renewable energy in Israel

Israeli usage of renewable energy is paradoxical. Although Israel is home to 270 smart or renewable energy technology companies, renewable domestic use is still at a fairly low percentage of the energy mix within the country, as compared to other countries in the world [48]. For comparison, Fig. 4 indicates the amount of total renewable production from 2008 to 2015 in Israel and Jordan as compared to Morocco, Syria, Lebanon and the United Arab Emirates [49].

Overall, Israel's potential in renewable energies lie in solar energy and wind. This section will examine each of these two options in greater detail and outline recent policy commitments to increasing renewable energy usage in the country.

4.1.1. Renewable energy national plans in Israel

Israel has a range of national plans and strategies regarding the promotion and development of renewable energy within the country. In Table 2, a summary of in force policies is provided. Different agencies in Israel's government has made various efforts to attain a higher usage of renewable energy and energy efficiency. The government has made renewable energy development more financially viable for both developers and consumers and provided pathways for cleaner transportation. Israel has a history of development, research and innovation when it comes to renewable energy. However, despite its progress in the private and academic sectors, the country overall has not achieved its renewable energy goals. For example, Israel's National Energy Efficiency Target 2020 target value was reducing energy by 20%. In 2014, it only reduced energy by 5.9%. Israel's National Renewable Energy Target 2020 target value was 10%. Although by the end of 2014, Israel only generated 2.24% of its electricity from renewable sources, it has the potential to hit its target goals by 2022 or 2023 [50].

In the Preparation of Master Plan for the Energy Sector in Israel, the Ministry of National Infrastructures declared that the energy policy focus is “to ensure reliable, high-volume production of energy for all sector consumers during routine and emergency times in the short and long-term while maintaining minimum costs for the sector and in view of the need to reduce dependency in foreign suppliers and to make use of more diverse energy sources” [51]. This language reflects Israel's energy policy focus on security: maintaining a stable access to supply both for short-term emergencies and for long-term sustainability. It also reflects a desire to keep costs low. Critically, Israel's energy policy is not headed by one governmental authority. The Ministry of National Infrastructure, the Interior Ministry, the Environment Ministry and the Ministry of Finance all have a stake in shaping the country's fuel outlook [52].

In 2004, the MNI published a set of rules that outlined tariffs, codes of conduct and licensing procedures for renewable energy [53]. The renewable energy targets and promotion policy, instituted

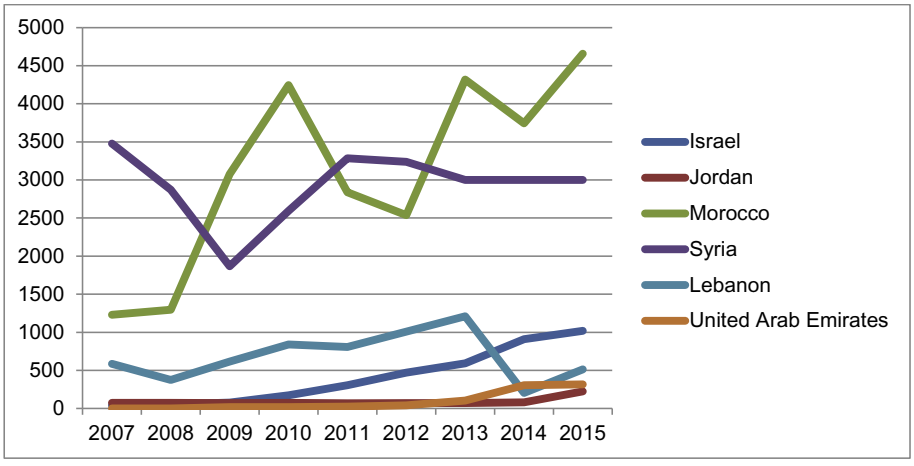

Fig. 4. Total renewable energy production in GWh in the Middle East from 2007 to 2015.

Table 2
In force renewable energy policies in Israel.

Name of Policy	Agency, Year	Description
Regulation on Domestic Solar Water – Heaters	Ministry of National Infrastructure, 1980	As a result of Planning and Buildings Regulation 5730–1970, there is a requirement of the installation of a solar water-heating system for all new buildings
State Subsidy for Electricity Generation from Wind and PV	Public Utility Authority, 2004	Approved state subsidy for renewable energy electricity generation to benefit private producers. Depending on demand periods, energy subsidy changes.
Renewable Energy Targets and Promotion Policy	Ministry of National Infrastructure, 2009	The policy endorsed a target of generation 10% of Israeli electricity from renewable sources by 2020 and 5% by 2014. These targets would require 4 GW of renewable energy capacity and 10 large solar power plants in the Negev to be built between 2010 and 2020. It also directed the Public Utilities Authority to create tariffs that would promote large-scale solar energy. Additionally, it provided incentives for entrepreneurs looking to build renewable energy power stations by speeding up the land approval process for all projects that create 500 MW of capacity.
Policy on the Integration of Renewable Energy Sources into the Israeli Electricity Sector	The Ministry of Energy, 2010	The policy implements the Government Resolution No. 4450 (SE/176), which set the generation of electricity from renewable energy and establishes a legal basis for a renewable tariff, tax benefits and policies supporting research and development.
Israel Net-Metering Regulation Framework	Public Utility Authority, 2013	This regulation replaced the 2009 feed-in tariff scheme and is capped to max 400 MW capacity. Consumers that own a RES system will receive credits for their surplus electricity generation.
Grant Support for Hybrid Taxis Purchase	The Ministry of Environmental Protection, 2016	This allocated 30 million NIS to subsidize purchase of hybrid taxis.
Communal Car Sharing Program	The Ministry of Environmental Protection, 2016	In collaboration with the Jewish National Fund, this allocated 8.6 million NIS to support car sharing projects, which would allow residents to rent electric or hybrid cars for short periods of time.
Grant Support for Electric Buses Purchase	The Ministry of Environmental Protection, 2017	This allocated 22.5 million NIS to the largest bus companies to buy 37 electric buses.
Israel Solar PV Auction	Public Utility Authority, 2017	The Israeli Electric Authority will hold solar PV auctions in 2017 and 2018, where developers could bid for projects with 23 year contracts.

in 2009 and still in effect today, was part of a plan in which the cabinet endorsed a target of generation 10% of all Israel's electricity from renewable sources in 2020. The target required 4 GW of renewable energy to be built between 2010 and 2020 and pushed forward solar thermal energy development plans. As a result, the government aimed to build 10 large solar power plants in the Negev. In addition, the plan sped up approval from the Lands Authority for projects that created 500 MW of capacity of renewable energy [54].

In 2010, the Ministry of Energy implemented the policy on the integration of renewable energy sources into the Israeli electricity sector. This policy was formed in order to implement Government Resolution No. 4450 (SE/176), which is about generating electricity from renewable energy. This policy was important because it set up the legal basis for a renewable tariff and tax benefits. The addition of a tariff is one of the most elemental pieces of the policy because it helps to equalize the cost discrepancy between electricity from renewable energy sources and from conventional generation [55]. Moreover, this government decision allocated $600 million energy spending on renewables over the next 10 years, which is targeted at a wide range of projects that work towards the outcome of achieving energy efficiency and GHG reduction [56].

Israel and Jordan signed and ratified the Paris Climate Agreement, the first unilateral, legally-binding global climate deal, in 2016. As a party to the agreement, Israel committed to reduce per capita GHG emissions by 26% of 2005 by 2030 [57]. In its plan to implement the Paris Agreement, Israel emphasized its goal of producing at least 17% of total electricity generation from renewables [58].

4.1.2. Solar energy in Israel

There are many advantages of solar energy within Israel. Although there are still necessary improvements to be made in order to increase cost parity between renewable sources, solar energy as a distributed technology is much more resilient to disruption than centralized technologies like nuclear, geothermal or hydroelectric energy. Israel, located in the solar sunbelt, similar to its Eastern Mediterranean neighbors, has among the highest rates of exposure to solar radiation in the world. The annual mean irradiance of solar energy is about 300 W/m^2 in the Red Sea Area, compared to 200 W/m^2 in Australia and 105 W/m^2 in the United Kingdom [59]. Average rates of solar radiation in the Jordan Valley in kWh/m^2 per day are indicated in Table 3, according to NASA. This shows that there is great potential for solar energy usage in the area. Ketura Sun, with installed capacity of 4.95 MW is Israel's first large-scale solar field and has 18,500 PV panels on over 20 acres of land [60].

Photovoltaic electrical facilities use photovoltaic (PV) cells or solar cells in order to transform solar radiation into electrical energy. Within Israel in 2011, the Ministry of Energy and Water Resources and the Israel Land Administration all provided guidelines on the construction of power stations in Mitzpe Ramon and Ein Evrona Industrial Zones. Operation of PV facilities with outputs exceeding 1 kW requires a permit from the Director of Electricity Administration at the Ministry of Energy and Water Resources [61].

Solar water heating in Israel is an important component of solar energy in Israel overall. The Israeli government mandated the use of solar water heaters in 1980 and leads the world in per capita use of solar water heaters, incorporating over 77% of all households [62].

Solar thermal energy comes in two forms: solar towers and concentrated solar power. Notably, the Ashalim Power Station project, in the Negev desert, is slated to be completed by the year 2018 and to be the world's tallest solar tower at 250 m. It is expected to generate 310 MW of power, or 1.6% of Israel's energy demand [63]. However, solar thermal energy requires a large amount of land, which is limited in Israel. For comparison, the Ketura Sun PV farm takes up .08 square kilometers of land whereas the Ashalim Power Station requires 3.15 square kilometers of land [64]. Israel offers small-scale consumers of solar power the ability to benefit from a feed-in tariff. However, the feed-in-tariff was implemented relatively late, in the year 2008. However, it worth noting that limited land is one of the main challenges to adopting

Table 3
Daily Average Rates of Solar Radiation in the Red Sea Area (kWh/m^2).

Month	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Annual average
22-year average	3.83	4.20	5.33	6.46	7.84	8.72	8.55	7.84	7.19	5.82	4.64	3.74	6.18

more renewable energy projects in Israel.

4.1.3. Wind energy in Israel

Energy production potential from wind power in Israel is far less than solar energy. In comparison to solar projects, harnessing energy from the wind has been less important to the Israeli government. Overall, Israel's maximum wind capacity is 600 MW. The country is faced with the obstacles of limited land availability for wind turbines and difficulty connecting to the grid [65]. However, wind power is a component of Israel's renewable energy strategy. In the 1990s, Israel installed wind turbines in the Golan Heights but the wind turbines used outdated technology. Then, in September 2010, Prime Minister Benjamin Netanyahu cleared a $400 million wind farm for fast-track approval, allowing two farms to provide 155 MW of power. Wind power does face boundaries to implementation. The opinion that wind farms are ugly and noisy is acts as an impediment for the government of Israel to rally popular support.

4.2. Renewable energy in Jordan

The need for renewable energy in Jordan is critical in developing a stronger base of domestic energy consumption, particularly because Jordan has a low level of indigenous oil resources. Because Jordan currently imports nearly all of its energy, strengthening renewable production is necessary and its national plans already reflect a growing commitment towards ramping up production. Specifically, this section will examine solar and wind. Under the guidance of the UNFCCC, Jordan's Intended Nationally Determined Contribution (INDC) is to reduce its GHG emissions by 14% until 2030. Jordan has outlined up to 70 projects in its *Climate Change Policy of the Hashemite Kingdom of Jordan 2013–2020* [66]. Critically, Jordan's goal is that renewable energy should meet 10% of energy demand by 2020. This could be fulfilled with projects with installation capacity of 600–1000 MW wind energy, 300–600 MW solar energy and 30–50 MW biomass energy [67]. The kingdom of Jordan has identified that in order to meet its renewable energy targets, it will require between 1.4 and 2.1 billion US dollars of investment [67].

4.2.1. Renewable energy plans in Jordan

In Table 4, it is evident that the Jordanian government has taken steps to make renewable energy more affordable for both consumers and investors as well as making energy efficiency more prominent. The 2013 Arab Future Energy Index (AFEX) ranked Jordan as second in the Arab region for both energy efficiency and renewable energy trends [68]. Renewable energy policies in Jordan are critical not only because Jordan's population is rising but it is affected by a sizeable population of Syrian and Palestinian migrant refugees, which increase the energy demand within the country.

During the attacks on the Arab Gas pipeline in 2011, Jordan faced a crisis. The country is home to over 2 million Syrian and Palestinian refugees. As a result of the interruption to natural gas supply, Jordan lost 5 billion USD. In light of its growing energy instability, Jordan implemented its National Energy Strategy 2007–2020 in 2005. This national plan aimed to increase renewables in the energy mix to 7% by 2015 and 10% by 2020. These renewable energy goals are to be met with projects with installation capacities of 600–1000 MW of wind energy, 300–600 MW of solar thermal energy and 30–50 MW of energy from biomass [69]. The goals of this plan are fourfold. First the plan seeks to diversify energy resources within the country. Secondly, it aims to increase the share of local energy production, which is critical because the current domestic energy production is 4% of total energy. In conjunction with the second goal, the plan hopes to reduce dependency on imported oil. Lastly, the plan's final goal is to increase environmental protection [70]. Importantly, the National Energy Strategy outlines financial incentives for the use of renewable energy. The provisions of the energy strategy allow for a predetermined feed-in tariff, which affects how power plants sell electricity to NEPCO. Ultimately, incentives like feed-in-tariffs and build-own-operate (BOO) systems work towards the goal of allowing renewable energy technologies to achieve cost parity with fossil fuels, even if there was a dramatic fall in oil prices [71]. Jordan's National Energy Strategy is distinguishable from other countries in that it is legally supporting its renewable energy targets with the passage of the Renewable Energy and Energy Efficiency Law [72].

The law, established through Law No. 13, was passed in 2012 and amended in 2014 and created a Jordan Renewable Energy and Energy Efficiency Fund. The fund created a ceiling price for renewable technologies, supported net-metering initiatives for small renewable energy systems and different tax incentives and exemptions surrounding the use of alternative energy [73]. Moreover, the law created the conditions to allow private companies to negotiate directly with the Ministry of Energy and Mineral Resources in order to establish new renewable energy projects. It requires NEPCO to buy electricity from renewable energy projects and for the government to pay for grid connection costs [74].

In 2016, the Ministry of Water and Irrigation (MWI) put forth a policy in order to improve the energy efficiency with the water sector. The government of Jordan has identified opportunities to lower fossil fuel consumption within the water sector's pumping, boosting, treatment and distribution processes. The MWI has set a policy target to reduce energy consumption of billed water by 15% in 2025 and to raise the share of renewable energy resources in power consumption by 10% [75].

Furthermore, Jordan relies on support from international nongovernmental and governmental organizations in order to achieve its renewable energy goals. Overall, Jordan has solicited nearly $850 million worth of international investments in order to reach its solar and wind power energy targets [76]. The Renewable Energy and Energy Efficiency Fund that was established by Law No. 13 is funded by agencies like the World Bank, the French Development Agency and private investors [77]. In the summer of 2015, the World Bank announced a $250 million loan to promote efficient use of water and renewable energy growth. In the fall of 2015, USAID, Jordan's top donor, signed an agreement that will provide $429.7 million to support a wide range of Jordanian governmental activities, which also includes renewable energy [78]. Among USAID's accomplishments are conducting Jordan's first major detailed energy use survey of more than 2700 households, installing solar panels on two government buildings and providing technical assistance to 11 Energy Service Partners [79].

Although Jordan emits less than 0.01% of total global emissions, it has been committed to implementing international climate agreements since it ratified the Kyoto Protocol in 1993. In Jordan's

Table 4
In force renewable energy policies in Jordan.

Name of Policy	Agency, Year	Description
National Energy Efficiency Strategy	Ministry of Energy and Mineral Resources, 2005	The policy endorsed a renewable energy generation target of 7% by 2015 and 10% by 2020. The plan provided financial incentives, such as a 100% exemption from income tax over 10 years. Other components of the strategy include progressively removing oil and electricity price subsidies, providing grants or soft loans to renewable energy projects and expecting the industrial and commercial sectors to reduce energy consumption by 20%.
Renewable Energy and Energy Efficiency	Ministry of Energy and Mineral Resources, 2010	This law gave the Ministry of Energy and Mineral Resources the authority to issue tenders to attract development proposal and allowed companies to negotiate directly with the Minister of Energy. It also set up the Jordan Renewable Energy and Energy Efficiency Fund. It was amended to include that all renewable energy sources and energy conservation systems, manufactured locally and internationally will be exempted from all customs duties and sales taxes.
Directive Governing the Sale of Electrical Energy Generated from Renewable Energy Systems (Net Metering)	Electric Regulatory Commission, 2012	This allows consumers to connect to the RE grid as long as their generation does not exceed their consumption. It also provides for an increase in the tariff if the RE system is of Jordanian origin.
Directive for the Costs of Connecting Renewable Energy Facility to the Proposals and Competitive Tenders	Electric Regulatory Commission, 2012	This directive states that the RE distributor is responsible for all costs of equipment installed on the distributor side.
Bylaw on Regulating Procedures and Means of Conservation	Ministry of Energy and Mineral Resources, 2012	This law focuses on improving commitments to and awareness of energy efficiency by creating a national database of energy efficiency and better energy audit procedures overall.
Reference Priciest Record	Electric Regulatory Commission, 2012	The law sets a ceiling tariff for electric energy generated by wind, solar thermal, PV, biomass and biogas.

National Climate Change Policy of 2003–2020, it pledged to build an adaptive economy that is climate-risk resilient and enables the usage of renewables. After Jordan agreed to the Paris Climate Agreement, it further concretized its commitments to including vulnerable groups in the adaptation and mitigation processes, make climate change concerns mainstream and develop a strategy that ensures adequate financing of projects.

4.2.2. Solar energy in Jordan

Per year, Jordan receives 5.5 kw/m^2 and receives 2900 h of sunshine duration, or around 316 sunny days with 8 h of sunshine per day [67]. Jordan's sparsely populated desert areas, located near its major urban areas, make the building of large concentrated solar power (CSP) plants ideal. Like its fellow “Sun Belt” countries, Jordan's weather conditions are ideal for solar energy.

Photovoltaic systems can be used in two ways, in small-scale roof-mounted systems and in large scale power plants that produce energy in the MW range. If half of the total roof area of Jordan was utilized for solar energy, between 296 and 325 MW of electricity could be produced [80]. There is usage of decentralized PV systems in rural villages. Nearly 15% of all households in Jordan have solar water heating systems and in the Energy Master Plan, the government set a goal for 30% of all households to be equipped with a solar water heating system [81]. Power plant projects in Jordan are supported by the government's Build-Own-Operate (BOO) financing mechanism, which is a private-public partnership that allows for bids on renewable energy projects. If all of Jordan's free government land was deployed for large-scale PV solar projects, there would be 465–508 MW of capacity [80].

Jordan's most recent achievements in solar energy are summarized in Table 5 [82]. By 2016, the Jordanian government signed 12 power purchase agreements for PV project with a total capacity of 200 MW, predominantly in the southern Ma'an area. Other notable projects that are currently underway include a 5 MW PV Solar Power plant financed by a Spanish-Jordanian collaboration as well as both a 103 MW project in Aqaba and 200 MW project in Muwaqqar funded by the UAE/Abu Dhabi fund for development. The 200 MW plant's $128 million cost will be financed by a grant from the Abu Dhabi fund for development [83].

Additionally, multiple Jordanian ministries have encouraged the use of solar energy for water heating in schools, nursing homes and companies. Moreover, the Kingdom of Jordan projected a vision for the increased usage of solar energy through awareness campaigns and energy audits [84]. As of 2016, the Kingdom of Jordan also intended to conduct a feasibility study to assess the viability of solar heater systems in refugee communities and 20 renewable energy systems in schools in collaboration with the Norwegian government [85].

4.2.3. Wind energy in Jordan

Conditions in the Kingdom of Jordan have a strong possibility for success. There are a few areas in Jordan that have mean wind flow velocity between 7 and 8.5 m/s, which are ideal for wind power generation [86]. Moreover, as is the reality with solar power, Jordan has large amounts of desert land available for wind turbines that are located conveniently near the electricity grid. However, in 2014, Jordan's wind farm facilities only had a generating capacity of 1.4 MW [87]. However, a Royal Committee in 2007 determined the feasibility of six wind energy projects to generate electricity: Al-Kamshah project in Jarash (40 MW), the Al-Fujaij project in Al-Shobak (70 MW), the Al Harir project in Al-Tafeleh (150–200 MW), Wadi Araba project (40–50 MW), Ma'an project (100–150 MW), and Al-Mafraq project (100–150 MW) [88]. In Jordan's National Energy Strategy Plan, the government set a goal for wind energy to amount to 1200 MW of the nation's energy mix [68]. As of 2016, Jordan has four total operating wind power stations, Ibrahimya, Jofa, Ma'an and Tafeleh [89]. One of these power stations, the Tafila Wind Farm Project, is notable because it has a generation capacity of 117 MW and part of a public-private partnership led by the Jordan Wind Project Company. In Table 6, the breakdown of the four operating wind energy farms in Jordan is shown.

As Jordan continues to act on action plans to increase the share of renewables, wind energy generation holds a great deal of potential.

5. Policy recommendations

In light of Israel and Jordan's current plans, targets, and laws, there is still much room for progress in developing sound renewable energy policy. It is critical that both countries transition from long-term action plans towards concrete, implemented policy that

Table 5
In-progress solar energy projects in Jordan.

Information on Project	Generation Capacity	Partners	Status
12 Photovoltaic Project direct-offers and generation	200 MW	Multiple	Achieved in 2016
IPP PV project-direct proposals in Mafraq	10 MW	Philadelphia Solar Power Company	Round 1 achieved
Complete PV Solar Power plant in Azraq	5 W	Government of Spain	In operation since April 2015
4 PV projects in Mafraq and Safawi/ Azraq	200 MW total	Multiple	34 PV tenders were submitted in Round II and 4 MOUs were signed for operation in 2017–2018
PV project in Qweira/Aqaba	103 MW	UAE/Abu Dhabi Fund for Development	Contract signed and implementation began in December 2015 with operation expected in 2017
Solar Plant to produce electricity for Za'tri refugee camp	8–10 MW	German Government, German Development Bank, Belectric Gulf	Contract signed August 2016; implementation scheduled for 2017
Solar power plan in Muwaqqar	200 MW	Masdar	Achieving financial close; due for completion by 2018

Table 6
Wind energy farms in Jordan.

Name	Number of Turbines	Capacity in MW	Owner
Jofa	5	1	Central Electricity Generating Company
Ibrahimyah	4	.32	Central Electricity Generating Company
Tafila Wind Farm	38	117	Jordan Wind Project Company
Maan Wind Farm	7	66	Elecnor

is supported by legal, institutional and financial frameworks. Neither country is on track to reach its 10% target by the year 2020. In 2014 in Israel, renewable energy comprised just 1.8% of electricity generation [90]. In 2016 in Jordan, 4.7% of its electricity was generated by renewable energy [91]. This is a gap that can be addressed by appropriate policies. Policies that allow renewable energy to attain cost parity with fossil fuels, promote the deployment of electric vehicles and allow for greater institutional and legal support are imperative for ensuring long-term energy security.

According to Torani et al. (2016), the first-best policy recommendation is to subsidize research and development to increase renewable technology and affordability. However, policymakers have opted for second-best solutions, which include financial mechanisms such as consumer subsidies and feed-in tariffs [92]. The challenge remains in creating a reality in which fossil fuels are less cost competitive than renewable energy. Countries such as Germany, Costa Rica, Sweden, Scotland and Uruguay are setting ambitious long-term goals to generate renewable energy successfully. These countries can work to dispel myths that renewable technologies are less reliable or not connected to the grid. Although the progress each country has made towards increasing renewables in the past few years is laudable, it is not yet enough. Israel and Jordan can re-envision themselves as countries that not only develop solar and wind energy technology, but use it.

5.1. Cost parity

One of the greatest barriers to renewable energy deployment is attaining cost parity with fossil fuels. Between 2009 and 2014, the average cost of solar PV modules fell by almost 80%. During the same time period, the cost of wind turbines fell by 33% [93]. There is promise in developing affordable technologies but still barriers remain. Because Israel and Jordan have seemingly low-cost options in natural gas and oil shale, policymakers must make efforts towards making renewables more immediately cost effective. One form of doing this is through lowering the amount of subsidies given towards natural gas and oil and increasing the amount of subsidies allocated towards renewables. However, there is a lack of incentives to shift the balance because consumer electricity prices are currently low. Moreover, in Israel, the Israel Electric Company has a monopoly on electricity distribution.

Another way to encourage greater cost effectiveness is through taking actions on appropriate energy efficiency measures. The World Bank's Regulatory Indicators for Sustainable Energy (RISE) standards suggest creating a task force to monitor and assess energy efficiency within the country [94]. So far, the Israeli government approved an 800 million NIS budget for financial support for energy efficiency. It could go one step further by creating a robust task force completely dedicated to measuring and promoting energy efficiency within the country. If both countries focus on energy efficiency and energy savings, they can save money nationwide. Additionally, an increased and mandated uptake of solar water and air heaters for heating and cooling in buildings is another sensible policy strategy.

Lastly, there are a few different financing mechanisms that assist the development of new renewable energy projects. These include feed-in tariffs, net metering, quotas, government loans and grants for research and development, tax credits and rebates and auctions for public-private partnerships. Notably, Morocco has been consistently ranked as the leader in renewable energy policies in the MENA region [95]. Morocco's model of competitive auctions for large utility-scale solar projects is successful because of its robust government support and legal certainty for developers in attaining the required permits to commence their solar projects [95]. If Israel and Jordan can match Morocco's clear policies, strong commitment to providing financial backing and domestic capacity to ensure that concrete projects are achieved, they will be more successful in adding renewables to the energy mix.

Jordan has made multiple deals and proposals to increase the share of renewable energy and it is imperative that the government maintains its efforts to see these deals through. In terms of its goals, the government of Jordan has made a number of internal recommendations. These include supporting and enabling private sector investment in renewable energy, implementing the proposed wind energy projects, conducting study on thermal solar energy projects and electricity generation from biomass and developing a fund to aid projects that draws upon resources from external donors,

international agencies and government treasury funds [96].

5.2. Electric vehicles

Another motivating pathway for lowering country-wide emissions and improving energy efficiency is through the wide-scale usage of electric-run cars and buses. Globally, there were 1 million electric vehicles in 2015 and 2 million in 2016 [97]. Norway's car market, for example, is composed of 30% Zero Emission Electric Vehicles (ZEVs). Although many renewable energy sector policies are focused on the power sector rather than the transport sector, there is great need and potential regarding electric vehicles. Specifically, one of Amman's major sources of ambient air pollution is due to exhaust from internal combustion engines. Jordan is planning to introduce a ZEV in Jordan and develop 3000 charging stations both on and off grid to support an intended 10,000 ZEVs across the country [98]. It is important to note that a ZEV vehicle can significantly reduce environmental air pollution if the electricity is generated from clean renewable sources.

Not only can electric vehicles help reduce contributions to global emissions by lowering the amount of polluting fuels, but they can also affect the amount of renewable energy available within the power sector. Options such as vehicle to grid electricity supply and time-variable smart charging utilize existing electric vehicle technology as storage options. However, technological improvement alone is not enough. Policies and financial strategies should also provide support. Israel has passed recent legislation that supports municipal purchasing of electric vehicles. Policies that help reduce the cost of electric vehicles as compared to internal combustion engine vehicles, integrate electric vehicles swiftly into the national grid systems and provide advantages for parking and driving are of vital importance.

Moreover, one of Jordan's biggest barriers to achieving more renewable energy usage in the country is normalizing utilizing renewable energy as a major resource. Although the technology is there, the people of Jordan need to have more buy-in to see Jordan's solar and wind resources as viable forms of energy production. The government can strengthen baseline awareness about the financial incentives provided by the renewable energy and energy conservation laws and further implementing power purchases agreements on long-term renewable energy producers [99].

5.3. Integrating renewables into the national grid

Additionally, both countries could set more ambitious renewable energy policy targets in their national plans and provide legal consequences for not following up on their plans. Although Israeli startups innovate a large amount of green technology, the government could aim for 25% renewable energy by 2020 rather than 10%. Jordan's plans are concurrently forward-thinking, but can also use more legal imperatives to make the government more accountable to its pledges.

Another important element of renewable energy policies is ensuring that the energy is properly connected to the grid, which is context-specific. Israel is not as readily able as Jordan to connect wind power to the grid because there is not viable land for wind power technology nearby urban areas. Currently in Jordan, the Ministry of Planning and International Cooperation is responsible for the direction and coordination of the electricity grid and renewable energy resources [100].

Israel can look to the Eilat-Eliot region as a model for the rest of the country. In the Eilat-Eilot region, 70% of electricity generation is powered by renewables [101]. This is an ideal case study because the region uses a mix of energy sources and the abundant solar resources within the region. Importantly, Israel should use the renewable energy technologies that work well for it. In Israel's case, solar energy is the most ideal. Moreover, there is potential for greater energy conveyance between and within the two countries. As noted in Fig. 3, electrical energy is already conveyed long distances. Israel could work to receive more of its energy from renewable electricity produced in the South and Jordan could benefit from Israeli-produced solar.

5.4. Energy security as the policy debate focus

Moreover, the policy debate should focus on energy security as a security issue rather than simply through cost efficiency. The available gas in the Tamar and Leviathan fields have altered Israel's energy future but does not change many of its hard realities. Israeli domestic energy supply is still vulnerable to attacks, which is why diversification is vital. If the energy debate only focuses on financial incentives, natural gas is more viable because the government receives tax benefits from natural gas utilization but not from renewable energy. So too, is the case with Jordan. Renewable energy is the most viable option for developing a diversified, energy independent Jordanian economy. If the debate in Jordan simply focuses on finding the cheapest options, it misses the need for utilizing existing domestic renewable energy resources.

6. Conclusions

This study has analyzed Israel's and Jordan's current energy demand and the relationship between renewable energy sources deployment and the supply security dimension. Presently, the two countries are mainly depending on fossil fuels to fulfill their energy requirements.

It is very well known that the environmental sustainability is the primary driver behind renewable energy sources deployment. In the case of Jordan and Israel, the vulnerable political situation puts a strong emphasis on the contribution of renewable energy sources to energy security through domestic electricity generation. Renewable energy provides a solution to Israel and Jordan's most urgent environmental, political and social challenges. Both countries have access to burgeoning technology as a result of research and development and a wide array of solar, wind and biomass resources. However, attaining a greater share of renewables within the energy mix of Israel and Jordan is not without its challenges. The increasing dependence of natural gas in both countries and attractive nature of nuclear and oil shale options have an effect on renewable energy deployment. Although both Jordan and Israel contribute very little to overall global GHG emissions, increasing the amount of renewable energy remains a critical component of maintaining commitments to the 2015 Paris Accords.

Heightened renewable energy is equivalent to heightened energy security. Today, both nations see a drier, hotter climate with more extreme potential weather events. Providing renewable energy can be more affordable and accessible to the poor. Israel and Jordan need to follow up with the intentions they outlined in their national climate change and energy strategies and secure domestic and international funds for renewable energy projects.

Expanding the share of renewables in the energy mix can bring extensive socio-economic benefits to Israel and Jordan. This includes improved air quality and public health, improved energy security through fuel diversification, jobs in new growth industries with export opportunities and climate change mitigation through GHG emissions reduction. Because Israel and Jordan still foresee considerable increases in electricity consumption in the upcoming years and, therefore, it is necessary to increase the share of renewable energy sources in the electricity sector in order to guarantee electricity supply.

The global conceptualization of security has become more open and in increasing need for new security challenges such as environmental and energy security. The unsustainable use of fossil fuel resources in Israel and Jordan leads to environmental insecurity in the region. However, through using creative policy options that encourage renewable usage, Jordan and Israel can provide energy that is more affordable and more peaceful.

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